Bacterial diversity and profile characteristics of urban soils in New York City

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Northeast Regional Soil Survey Workshop, June 20, 2016 – Lake Placid, NY

Objectives

1) To collect **dynamic soil properties** (DSP) and **microbial community data** down through the profil.
   - **parent materials:**
     - naturally deposited (NDM)
     - human-altered and human-transported (HAHTM)
   - **management of vegetation cover** (woodland, turf,…)

2) To determine the microbial diversity and **relative species abundance** and **correlate the microbial communities with the profile characteristics and DSPs**

Sampling sites across NYC

Soils formed in naturally deposited materials (NDM)

***Soils formed in human-altered and human-transported materials (HAHTM)**

Samplings & Soil Analysis

- October 2013: **4 soils** formed in NDM (e.g. till, outwash) under **woodland or shrubby cover**
- June 2014: **4 soils** formed in HAHTM (e.g. coal ash, construction debris) with **high artifacts (>10%) fill** under **managed** (turf) or **unmanaged** (weed, forest) **vegetation cover**

- **Sampling of each horizon for microbial analysis** (15-mL Falcon tube) **and soil analysis** (1 kg)

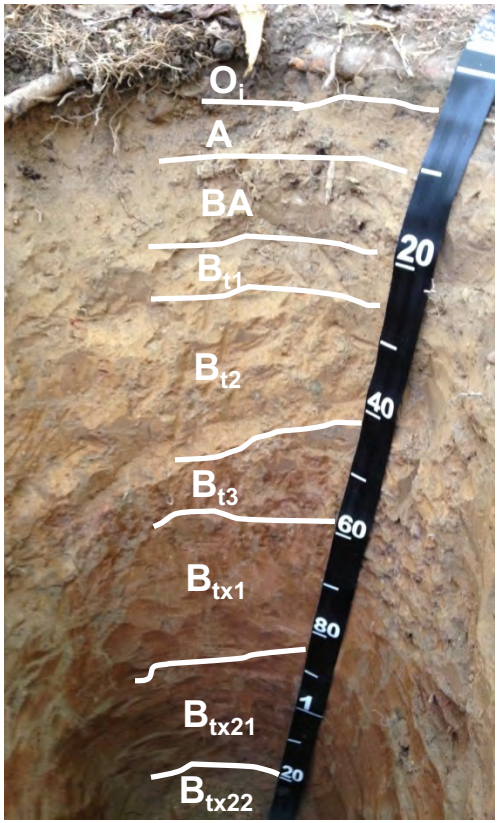
- **Soil analyses on fine fraction (< 2 mm)**
  - heavy metals content (P-XRF)
  - pH (1:1 v/v in water) and salts (1:2 v/v in water)
  - carbonates (volumetric method, NF ISO 10693)
  - organic carbon (loss on ignition at 550° C)

Soil profiles

Haledon

Blue Heron Park, Staten Island

Parent materials: **glacial till**

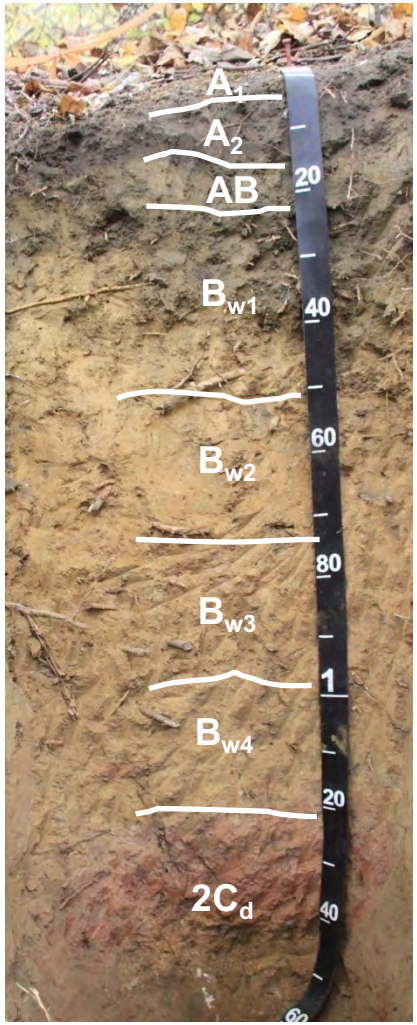


Water table at 42 cm
Fragipan between 57 and 155 cm
Woodland cover

Charlton

Inwood Hill Park, Manhattan

Parent materials: **eolian deposits over till**

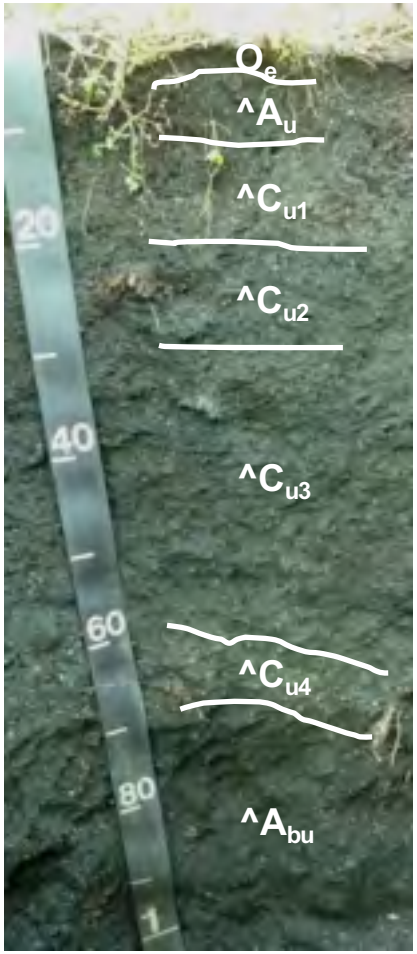


Woodland cover

Rikers

Greenbelt, Staten Island

Parent materials: **coal ash**

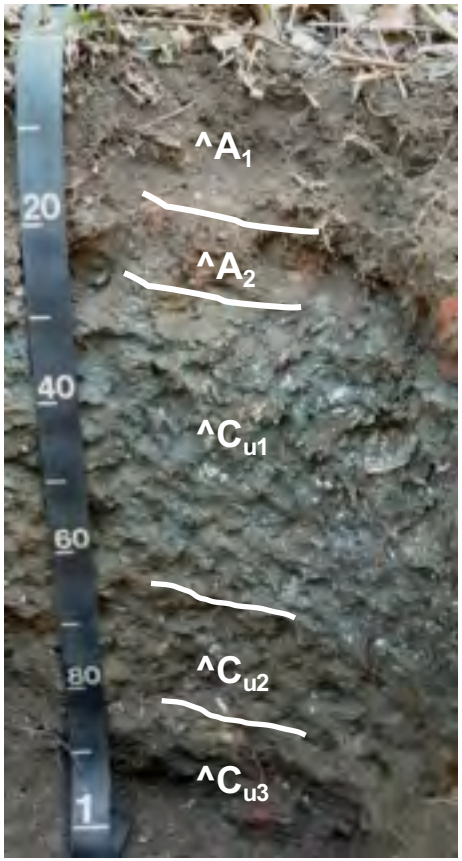


Unmanaged tree cover

Laguardia

Soundview Park, Bronx

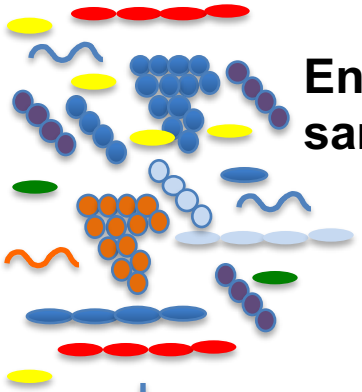
Parent materials: **construction debris**



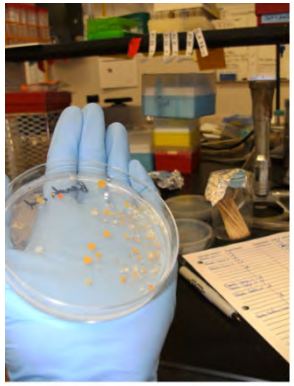
Weed/trees cover

Identifying Soil Microorganisms

- What is the uncultured majority?
- Complex bacterial communities may contain hundreds or thousands of different bacterial species.
- Typically <5% of this diversity can be cultured in the lab.
- So, how can we learn more about this uncultured majority?



Environmental sample

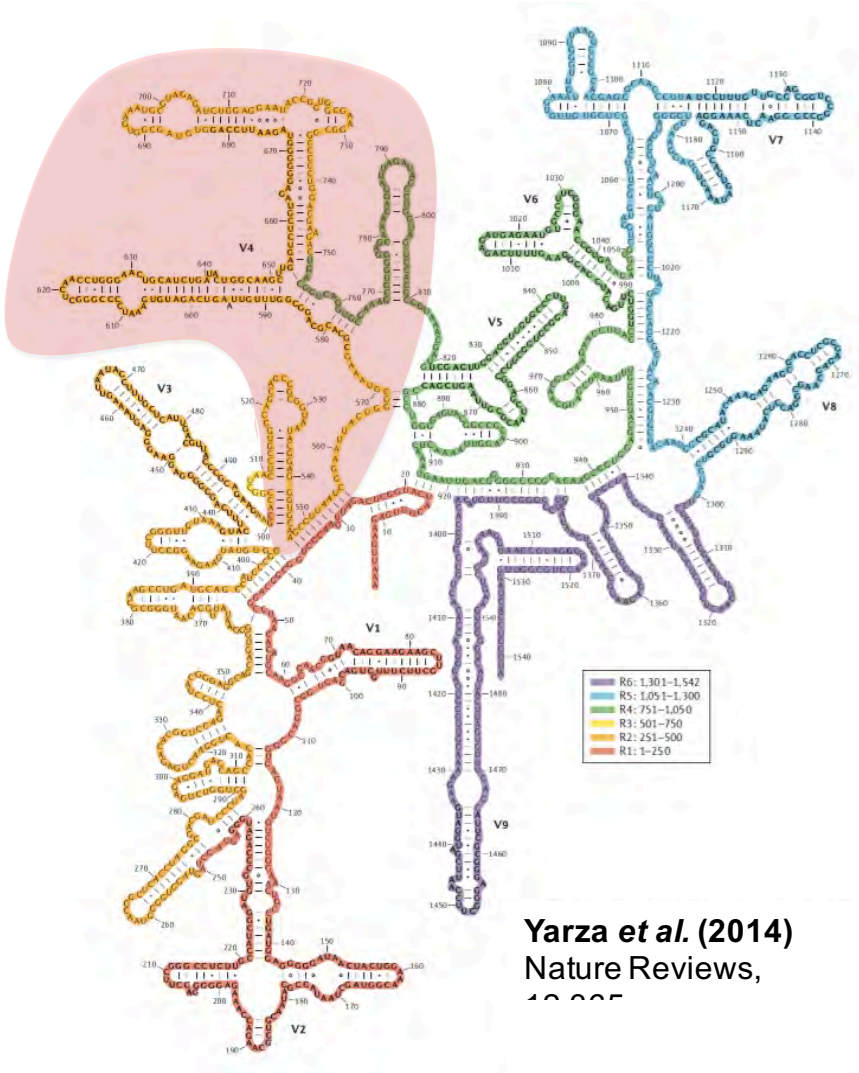


Culture in the lab

DNA as a proxy for microbial community members

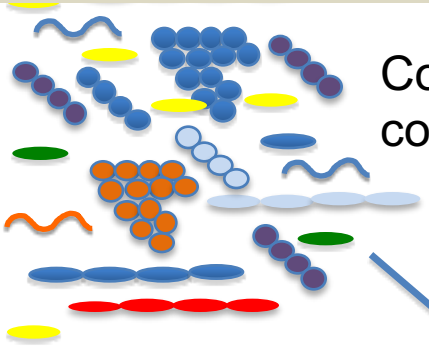
- **DNA sequencing**

- Genomic DNA sequenced using Illumina MiSeq technology
- 16S rRNA gene
  - Variable regions (V1-V3/V4)
- Pairend reads



Yarza *et al.* (2014)
Nature Reviews,

Microbiome Analysis Pipeline

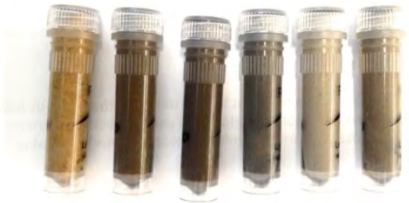


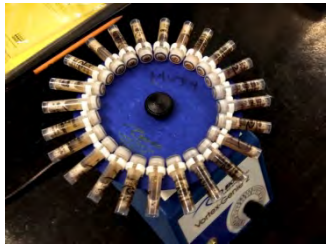
Complex soil bacterial community

Collect sample and extract DNA

Next generation Illumina MiSeq sequencing of DNA

Hundreds of thousands of DNA sequence reads





Obtaining DNA

-PowerSoil® DNA isolation kit (MO BIO)

-0.250 g of soil sample per horizon

Microbiome Analysis Pipeline (2)

Hundreds of thousands of DNA sequence reads

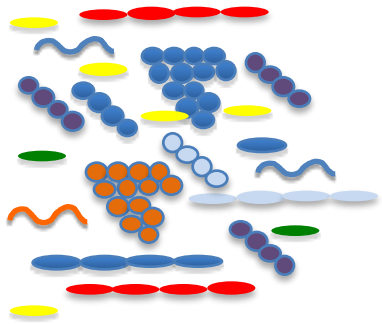
AGGCTT → 8
ATTGAA → 1
CGGTAA → 28
TTAAAC → 5

Cluster/bin similar sequences (>97% identity)
Relative abundance
QIIME software

Compare DNA sequences to bacterial sequence database

BLAST

Basic Local Alignment Search Tool



Taxanomic identification:
Bacilus
Staphylococcus
Clostridium
Streptomyces
Etc…

DNA sequence information serves as an indicator for the presence of organisms, metabolic pathways, enzymes, virulence factors, …

DNA sequencing and Bioinformatics

- **Bioinformatic pipeline**

- Sequence data processed with QIIME (Quantitative Insights Into Microbial Ecology)

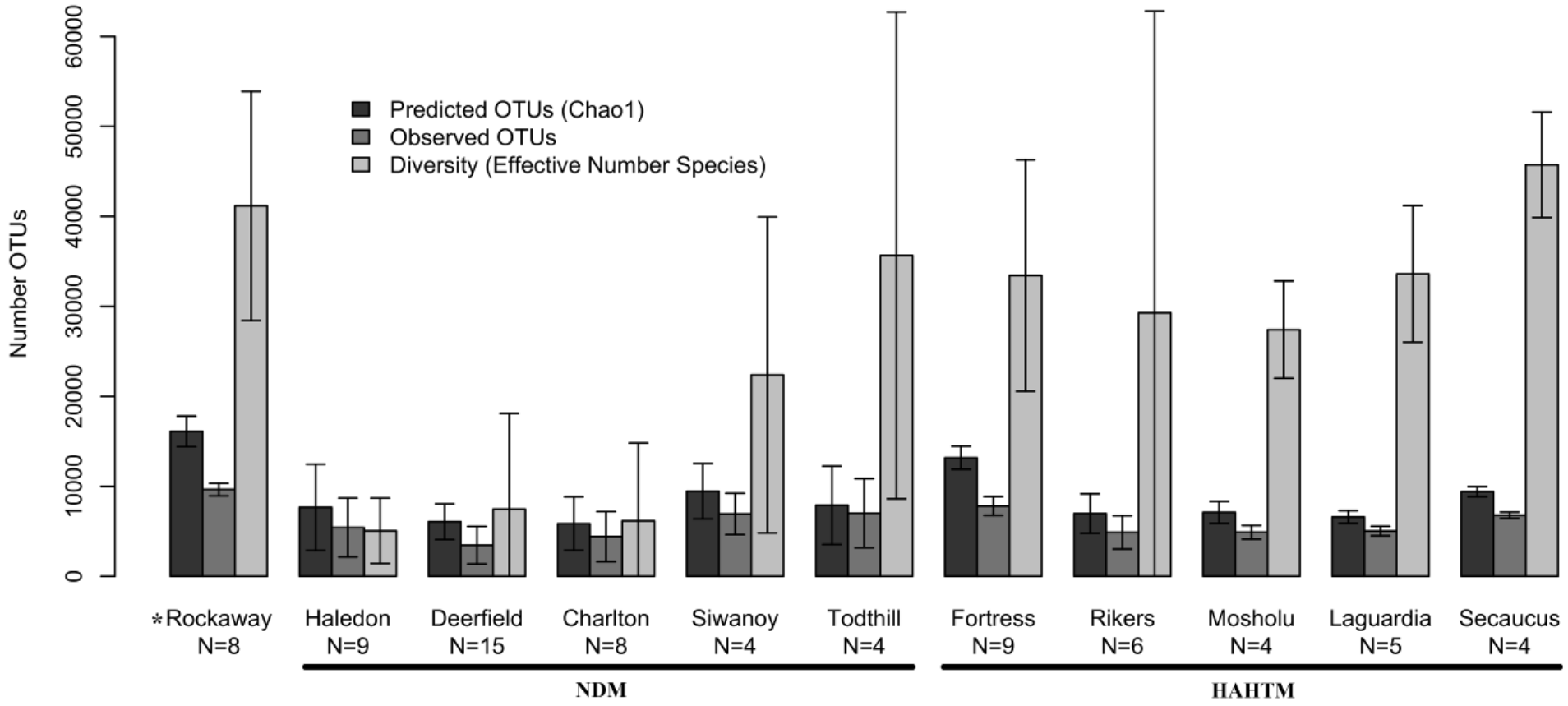
    - Paired sequences
    - Quality control
    - Assignment of operational taxonomic units (OTUs)
    - Identify taxonomy of OTUs
    - Assess biodiversity

Dynamic Soil Properties

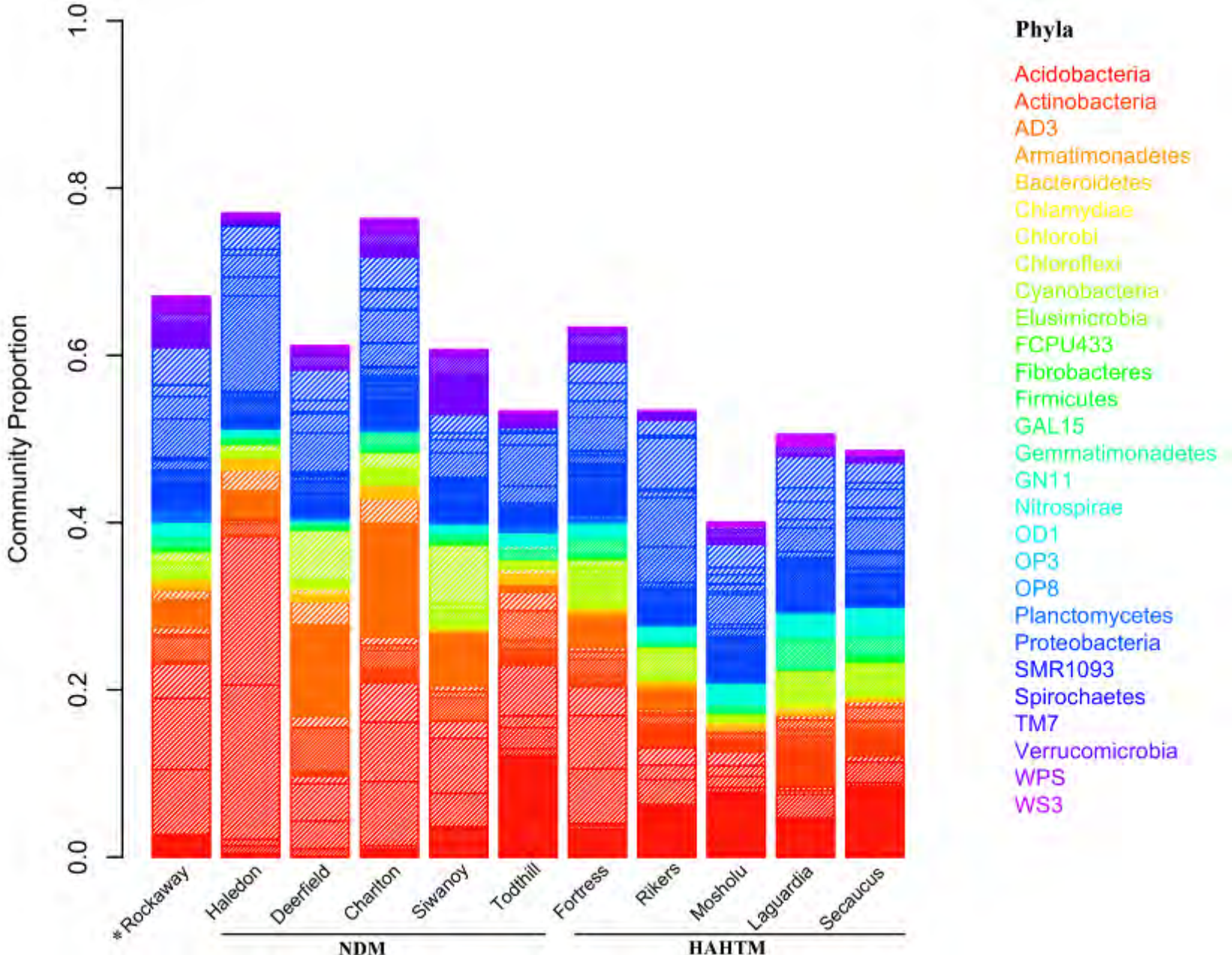
- Higher proportion of **coarse fragments** in soils formed in HAHTM, including a **high proportion of artifacts** (e.g. coal, slag, glass, bricks, concrete)
- **Soils formed in NDM and in coal ash are acidic** whereas **soils formed in construction debris are slightly alkaline**, in relation to the presence of **carbonates** (e.g. concrete)
- **Accumulation of org. C** at the surface is generally higher in NDM soils

	Haledon	Deerfield	Todthill	Charlton	Rikers	Mosholu	Laguardia	Secaucus
parent materials	glacial till	outwash	serpentine	glacial till	coal ash		construction debris	
vegetation	forest	forest	shrub	forest	forest	forest	weed	turf
org. C (%)	1 - 32	0.4 - 42	3 - 16	1.5 - 19	4 - 9	2 – 24	3 - 5	2 - 9
pH (-)	3.5-4.3	3.5-5.3	5.3-6.7	3.7-4.8	4.6-5.1	4.4-6.1	7.0-7.7	6.2-8.2
salts (mg/L)	11-44	21-1010	7-12	17-145	15-80	23-106	102-127	87-165
carbonates (g/kg)	-	-	-	-	-	-	6-33	1-82
coarse fraction (%)	0-7	0	0-45	0-2	35-50	15-75	15-60	0-70

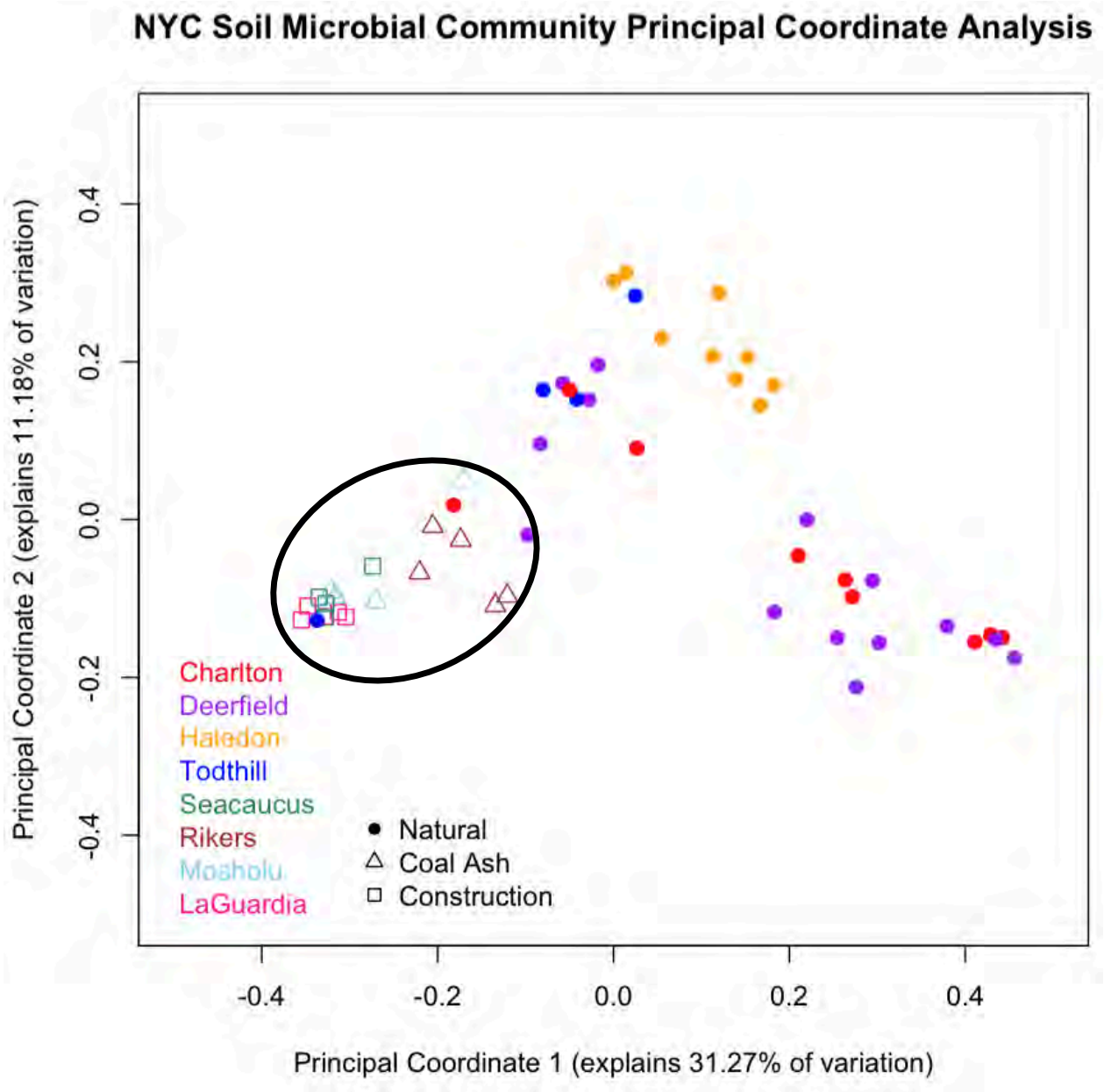
Bacterial Community Biodiversity



Bacterial Community Composition



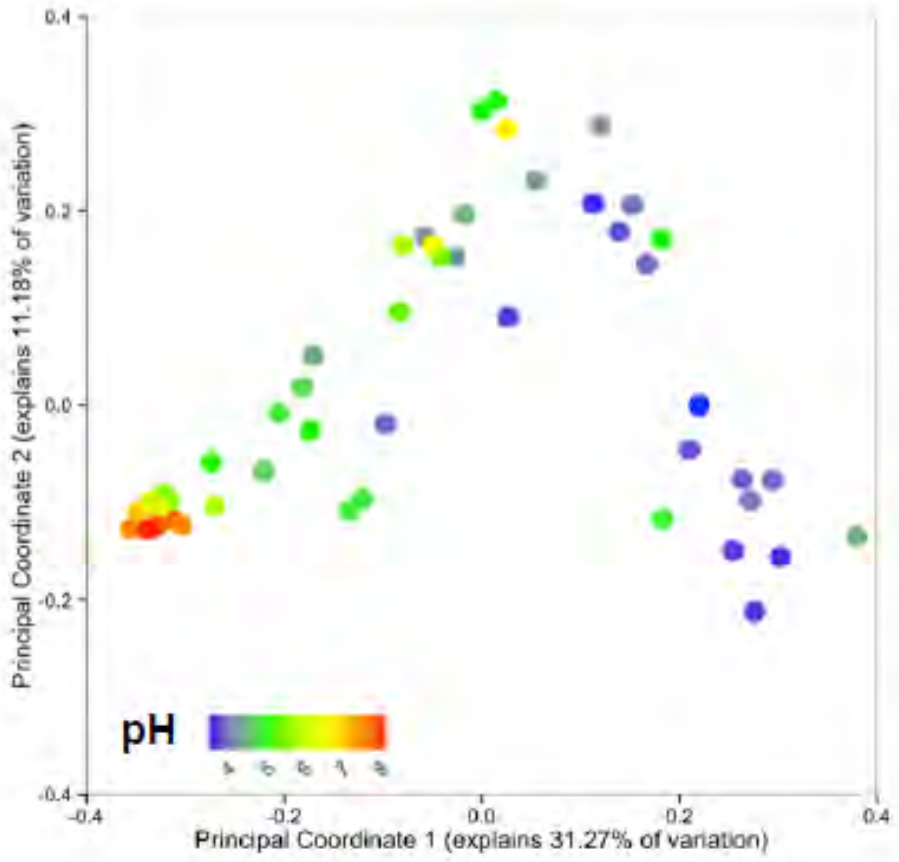
Biodiversity – Bacteria Community Similarities: PCoA

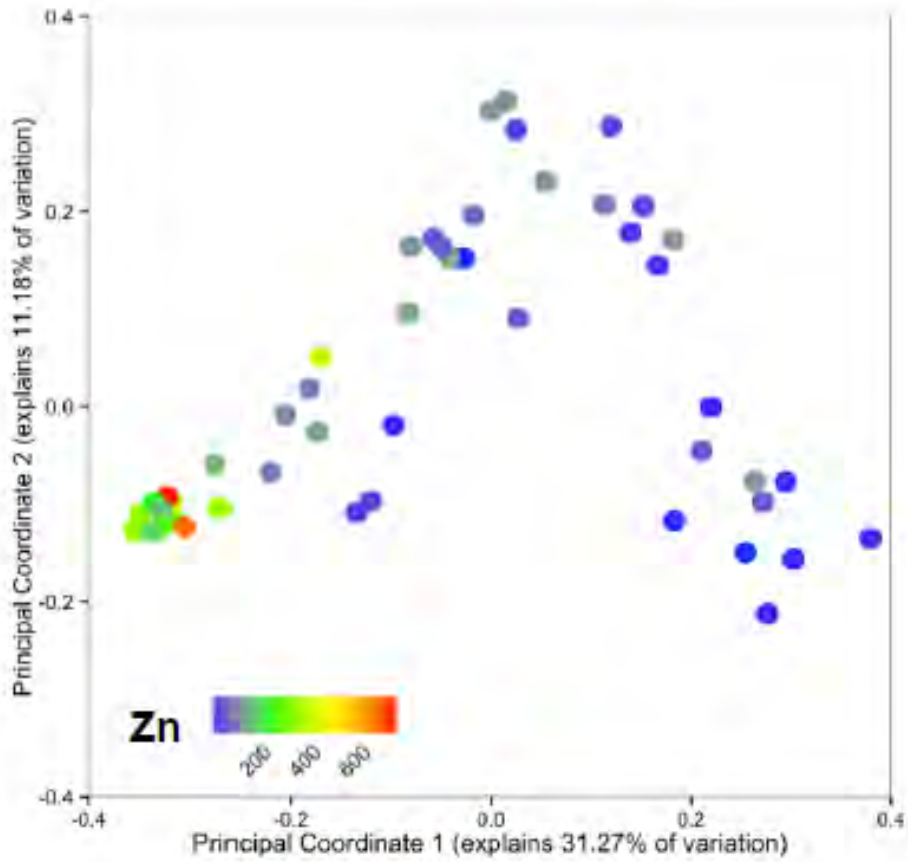


Correlation bacterial diversity and DSPs?

PERMANOVA:

- correlation between diversity and pH (p=0.006)
- correlation between diversity and Zn content (p=0.013)





Acknowledgements

USDA – NRCS:

Lisa Krall (NRCS, Tolland, CT)
Edwin Muniz (NRCS, Somerset, NJ)
Fred Schoenagel (NRCS, Hackettstown, NJ)
Marissa Theve (NRCS, Tolland, CT)
Olga Vargas (NRCS, Greenwich, NY)
and **Ron Taylor** (NJ State scientist)

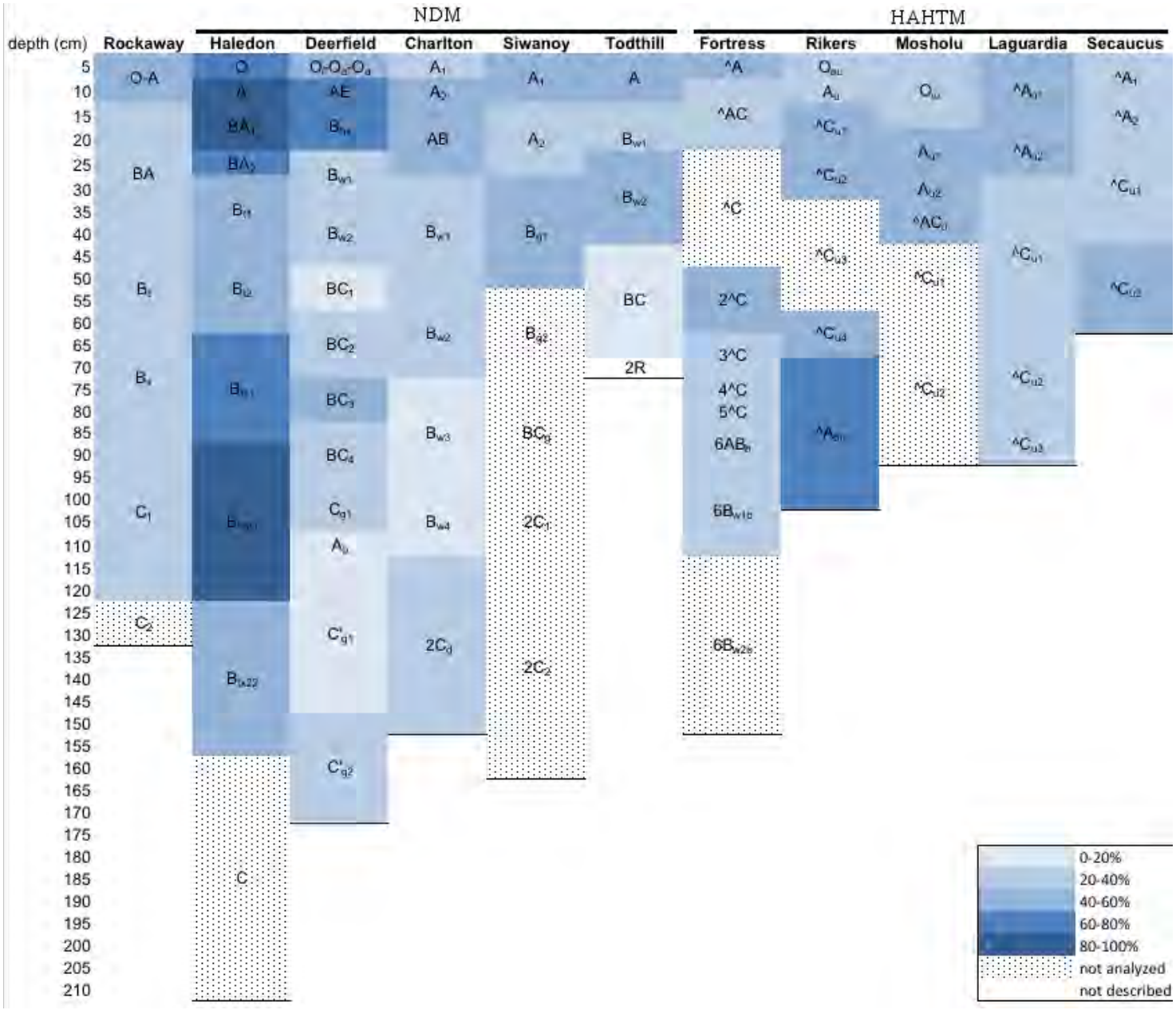
Brooklyn College:

Zulema Su for the mapping of sampling sites

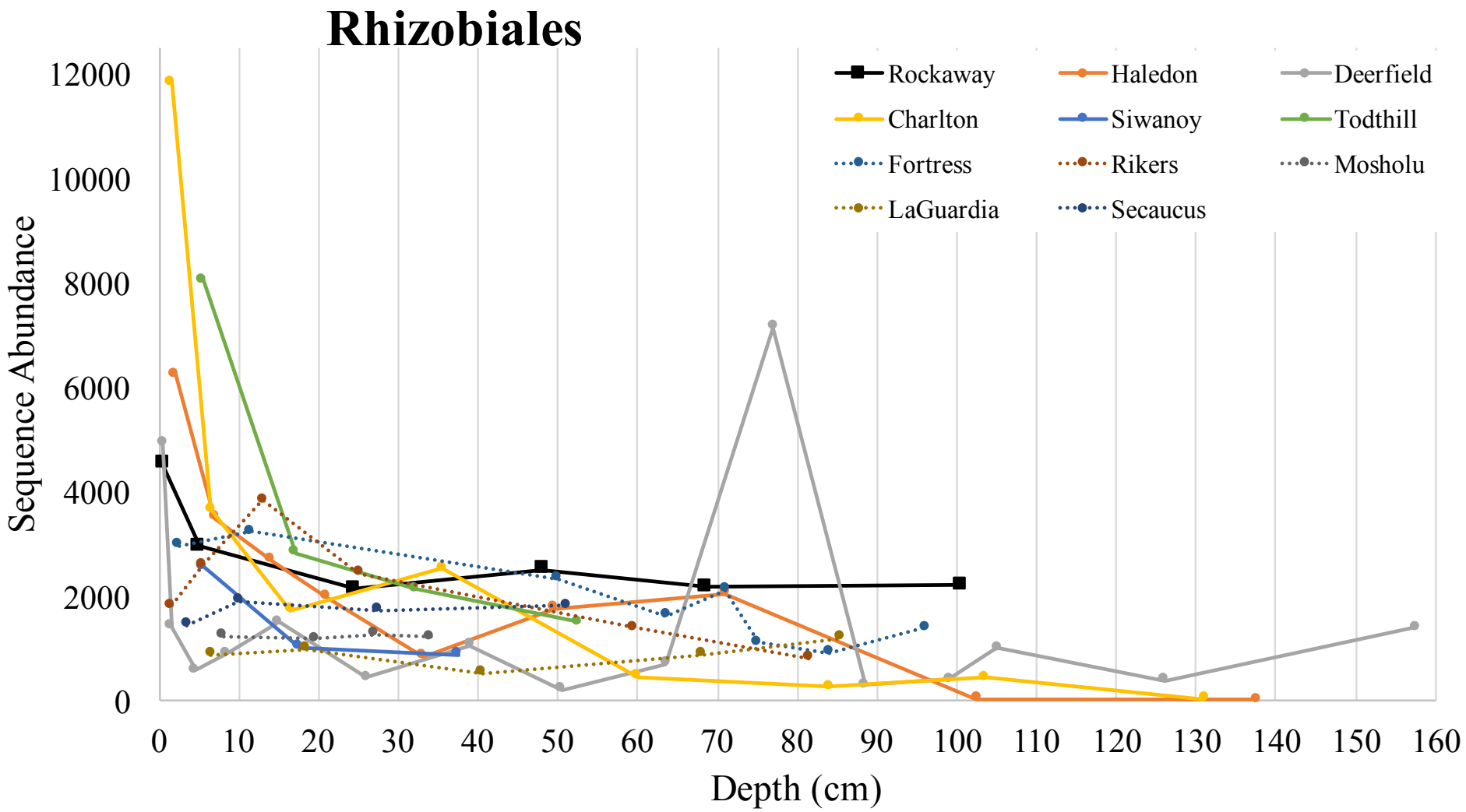
Thank to all the PhD, graduate, undergraduate and high school students who help us to sample and to analyze the soil samples:
Nadia Brijmohan, Vivian Cheng, Sara Perl Egendorf, Kayo Green, Michael Grinshtein, Xiao Yan Hu, Asia Le, Ying Liu, Tamar Saimbert, Andres Saldarriaga, Kai Saunders, Eridi da Silva, Zulema Su, Sefer Tunca, Susan Valkai, Yuanwei Wang, Zaw Win and Gal Zeidman.

Thank you for your attention

Top Bacteria Presence Through Pedon Depth



Bacterial Community Composition



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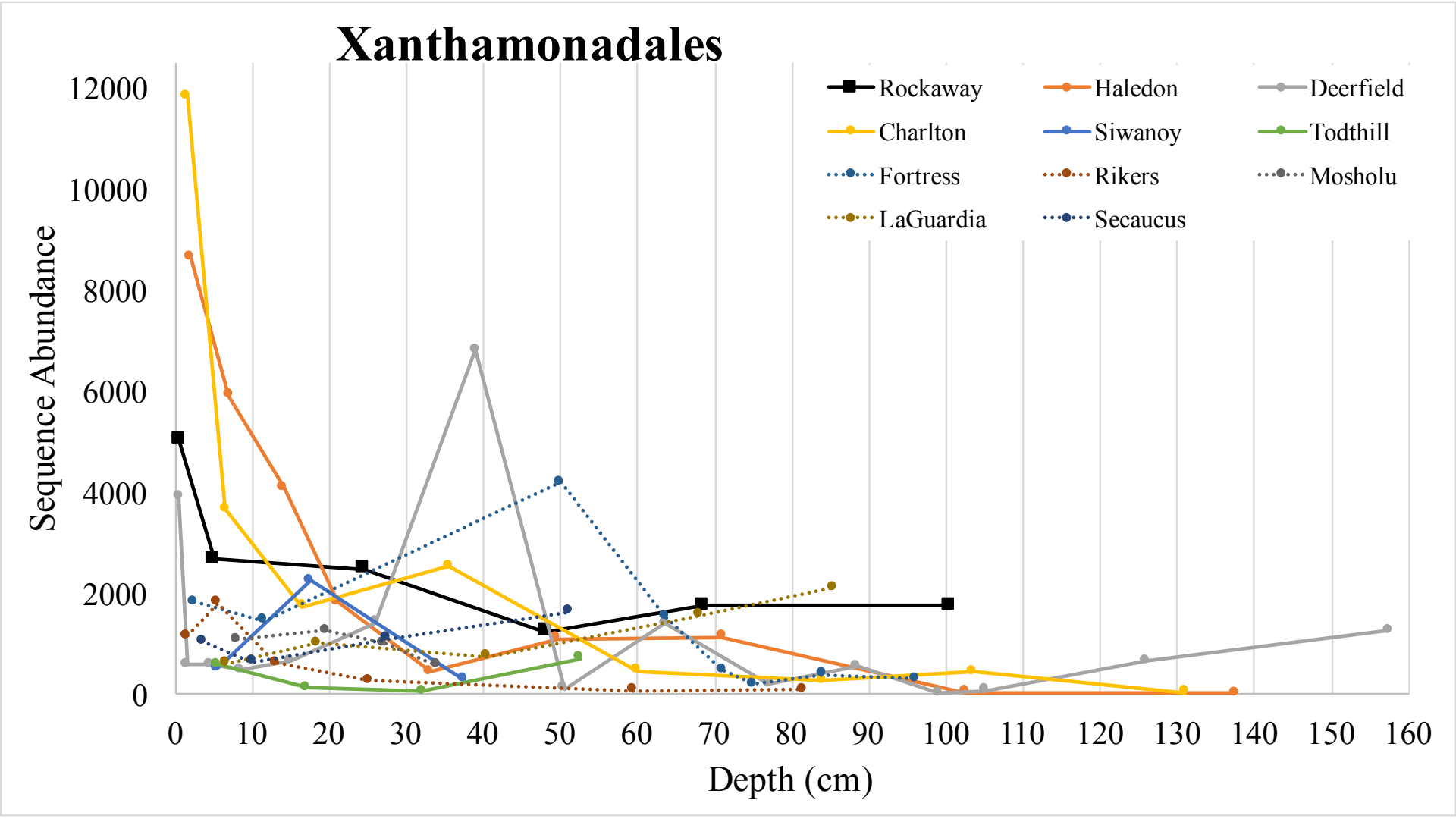
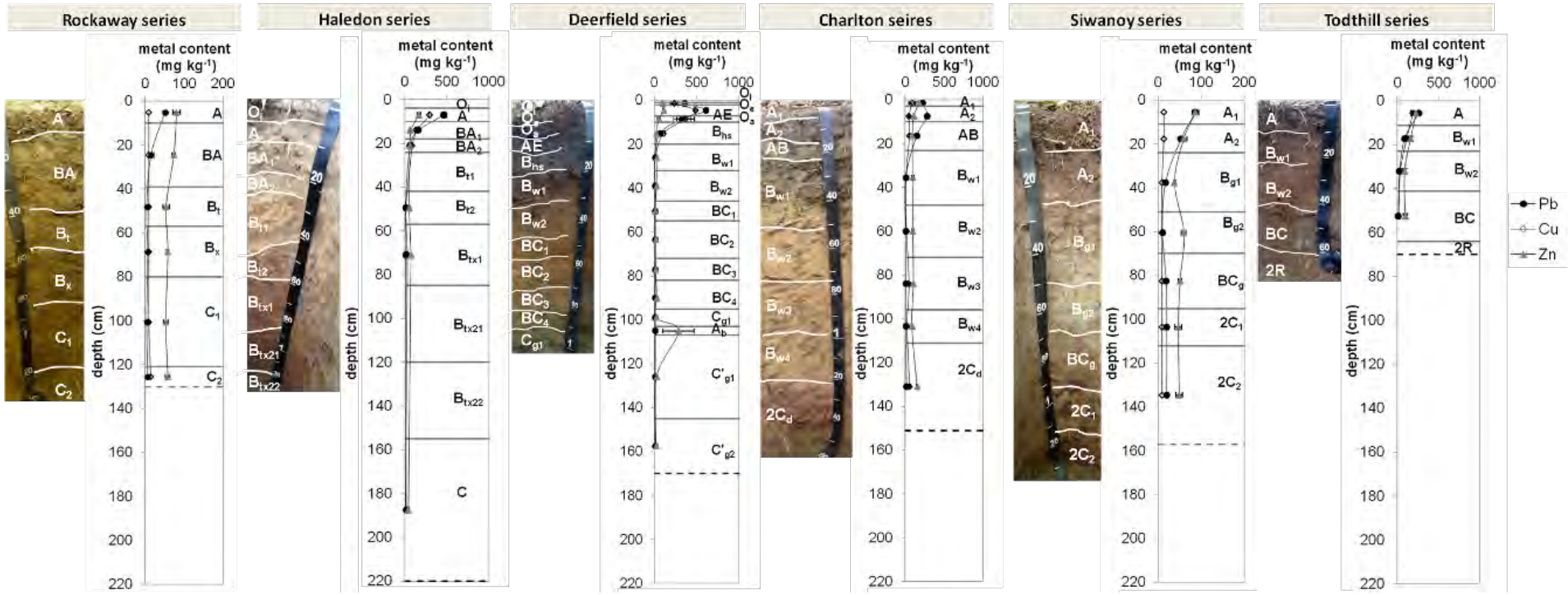


Urban Soil Series Profiles – Natural Parent Material



Urban Soil Series Profiles – Anthropogenic Parent Material